




# MATURITY CURVE METHOD OF DEVELOPMENT - CERTIFICATION

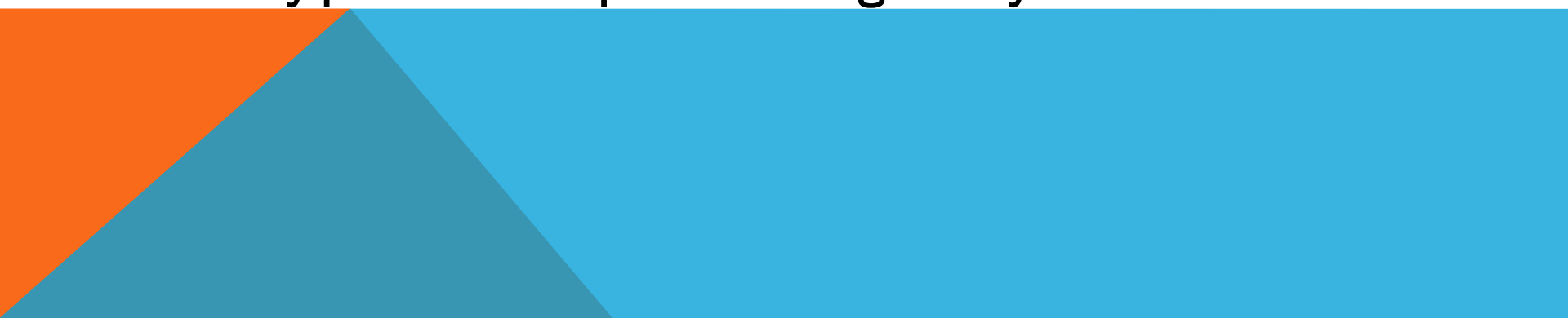
PRESENTED BY TIM KRASON



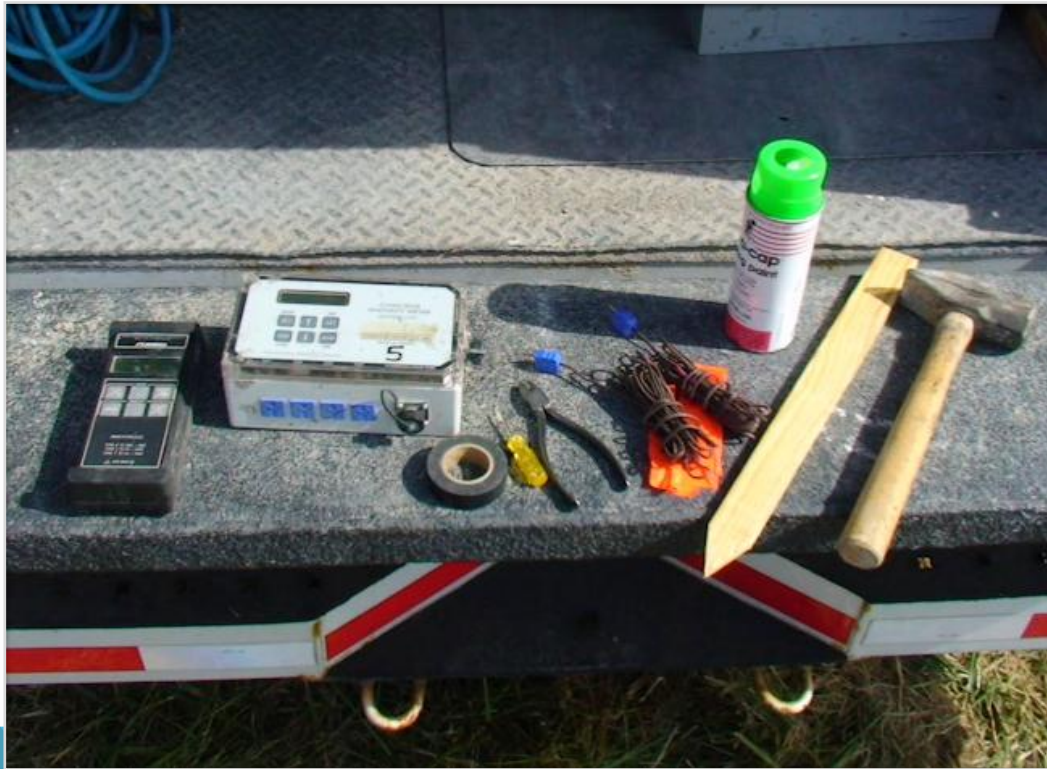
# OUTLINE

- **Significance and Use**
  - **Equipment**
  - **Procedure for Development of the Curve**
  - **Methods for Monitoring the Concrete Temperature**
    - Maturity Meter
    - Digital Thermometer (Hand Calculated Method)
  - **Steps for Plotting the Maturity Curve**
  - **Steps for Validating the Maturity Curve**
- 

# MATURITY METHOD- SIGNIFICANCE AND USE

- Useful means of estimating concrete strength gain at early ages (generally less than 7 days).
  - Provides real time in-place strength of concrete for pavements or structures.
  - Determines the appropriate time for opening pavement to traffic, sawing joints and stripping forms.
  - Currently is used by NDOR for acceptance testing for only pavement repairs and high early concrete.
- 

# EQUIPMENT



# EQUIPMENT





# PROCEDURE REQUIREMENTS

- **Locations**

- Ready Mix Plants
- On site



- **Mix Design**

- Fresh concrete tests must meet specifications (Air, Slump)
- Water Cement Ratio (W/CM)
- Workability



- **Specimens**

- Cast a minimum of 10 cylinders(4x8)
- 14 maximum



- **Installation**

- Embed 2 thermocouple wires

# PROCEDURE REQUIREMENTS- *CONTINUED..*

- **Curing:**

Cure the cylinders to best represent the concrete placement


- **Paving or Structures**

- On Grade
- Insulated Box
- Curing Blankets
- Near Structure
- In a Trailer

- **Pavement Repair (PR) and High Early Concrete (HE)**

- Insulated Box
- Curing Blankets

After casting cylinders, move cylinders immediately to final location for curing





# MATURITY METER

This is the preferred method for monitoring concrete temperature.

- **Maturity Meter datum temperature setting shall be set to -10 C.**
  - Connect the mini-connectors to Channel 1 (CH 1) and to Channel 2 (CH 2) on the maturity meter.
  - Start the recording on Meter. (Write down the initial temperature and time taken)
- *Other commercially made Maturity Meters you may install Plugs or sensors in the concrete. Monitoring process will be slightly different based on the equipment.*
- **For Reference: The age to test the first set of cylinders for compressive Strength is determined from when the maturity meter recording is started.**
  - Cylinders for PR concrete may be moved 2.5 hours after casting.
  - Cylinders for HE and Paving concrete may be moved 8 hours after the concrete has reached final set.
- **For Reference: The approximate ages when to perform compressive strength testing on your first set of cylinders.**
  - PR concrete may begin at three or four hours depending on the time of year and the type of cement used.
  - HE concrete may begin at twelve to twenty-four hours.
  - Paving concrete may begin at twenty-four hours.

## MATURITY METER



# MATURITY METER

- TTF (Time-Temperature-Factor) is computed by the Maturity meter.
- TTF values along with cylinder comp. strengths is then entered into Maturity Curve Spreadsheet.

NDOR MATURITY METHOD - COMPRESSIVE STRENGTH DEVELOPMENT										
PROJECT: STPD-6-2(122) Culbertson to McCook										
CON. NO.: 70881		CONTRACT NO: 7881			CONTRACTOR: Ten Point			CURVE NO.: 1-Open		
								DATE: 06/11/11		

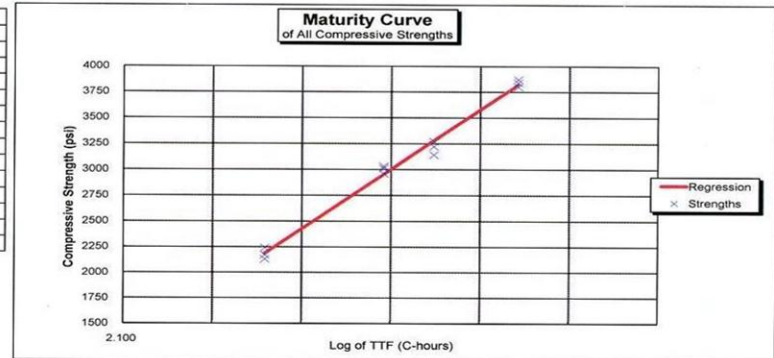
  

Cylinder #	LOAD AT BREAK (lbs)	BREAK TYPE	Length (in)	Diameter (in)	Compressive STRENGTH (psi)	AGE AT BREAK (Hrs)	TTF CH 1	TTF CH 2	AVERAGE TTF	Cylinder TEMP (AVG)
1	Enter		Enter	Enter		Enter	Enter	Enter		Enter
2	27260		8.00	4.00	2170	4	181	181	181	53 C
3	26720		8.00	4.00	2130	4	181	181	181	
4	28110		8.00	4.00	2240	4	181	181	181	
5	37180		8.00	4.00	2960	5	246	246	246	
6	38070		8.00	4.00	3030	5	246	246	246	
7	37870		8.00	4.00	3010	5	246	246	246	
8	41040		8.00	4.00	3270	5.5	280	280	280	
9	40420		8.00	4.00	3220	5.5	280	280	280	
10	39470		8.00	4.00	3140	5.5	280	280	280	
11	47810		8.00	4.00	3800	6.5	348	348	348	58 C
12	48640		8.00	4.00	3870	6.5	348	348	348	
	48225		8.00	4.00	3840	6.5	348	348	348	



MIX INFORMATION	
Mix:	Enter
AIR:	PR1 W/ Liquid Calcium
SLUMP:	6.4
w/c:	
FLY ASH SOURCE:	
CEMENT SOURCE:	
COARSE AGGREGATE SOURCE:	
FINE AGGREGATE SOURCE:	
WATER REDUCER BRAND:	
Add. Rate:	
AIR ADMIXTURE BRAND:	
Add. Rate:	
METHOD OF DEVELOPMENT:	Cylinders / Cure Box
DESIRED COMP. STRENGTH (psi):	3000 psi

REQUIRED MINIMUM TTF: 251



Materials & Research Representative - Tim A. Krason

Signature

Contractor Representative -

Signature

Comments: Weather - Approx 74 F for High.

Added Glenium 3030 on site.

See sitemanager entry for mix information.

# HAND CALCULATED METHOD

Alternative method for monitoring concrete temperature



# HAND CALCULATED METHOD

- **Connect the mini-connectors**
  - **Designate Channel 1 (CH 1) and Channel 2 (CH 2)**
- **Record the time the initial temperature was taken for each designated channel.**
- **The temperature reading will be in Celsius.**
- **The TTF shall be calculated at each age that a set of cylinders are tested.**

# Hand Calculated Method

$$M(t) = \Sigma (T_a - T_o) \Delta t \text{ (Nurse-Saul Equation)}$$

**M(t)** = Time Temperature Factor at the age the calculation is performed.

**T<sub>a</sub>** = Average temperature using the initial temperature and the elapsed time temperature reading.

**T<sub>o</sub>** = Datum temperature of -10° C

**Δt** = A time interval (Hours)

# HAND CALCULATING EXAMPLE

$$M(t) = \Sigma (T_a - T_o) \Delta t \text{ (Nurse-Saul Equation)}$$

Example 1: The initial temperature of concrete is 19.7 °C (20.0 °C) and 3 hours later it was 50 °C.

$T_a$  = *Average Temperature*

$$T_a = \frac{(20 + 50)}{2} = 35^\circ\text{C}$$

$T_o$  = *Datum Temperature*

$$T_o = -10^\circ\text{C}$$

$\Delta t$  = *Time interval*

$$\Delta t = 3 \text{ hours}$$

*elapsed time is 3 hours from when the initial temperature was taken.*

$$M \text{ (TTF)} = \Sigma (T_a - T_o) \Delta t$$

$$M \text{ (TTF)} = \Sigma (35^\circ\text{C} + 10^\circ\text{C}) 3 \text{ hrs}$$

*always add 10 °C to the average. When subtracting a negative number add it.*

$$M \text{ (TTF)} = \underline{\underline{135^\circ\text{C-hrs}}}$$

# MATURITY METHOD - FIELD DATA SHEET

EXAMPLE

<b>Project :</b> EACNH-30-5(121) Columbus East	<b>Maturity Curve #:</b> 1
<b>Control #:</b> 32031 <b>Contract #:</b>	<b>Date Placed:</b> 10/10/2001
<b>Contractor:</b>	<b>Mix:</b> PR1-3500

**Target TTF Value :** 305

## *Section of Pavement to Open OR Structural Unit for Form Removal or Loading*

		From Station:				To Station:			
Probe #		<u>Date</u>	<u>Time</u>	<u>Age (hours)</u>	<u>Temp (deg C)</u>	<u>TTF at age (deg C-hr)</u>	<u>Sum TTF (deg C-hr)</u>	<u>Air Temp (deg C)</u>	
1		10/02/01	11:00 AM	0.00	21		0		
		10/02/01	01:00 PM	2.00	33	74	74		
		10/02/01	02:00 PM	3.00	42	47.5	122		
		10/02/01	03:00 PM	4.00	49	55.5	177		
		10/02/01	03:30 PM	4.50	53	30.5	208		
		10/02/01	04:00 PM	5.00	56	32.25	240		
		10/02/01	04:30 PM	5.50	57	33.25	273		
		10/02/01	05:00 PM	6.00	58	33.75	307		
						0	0		
						<u>TTF:</u>	307		



# NDOR MATURITY METHOD - COMPRESSIVE STRENGTH DEVELOPMENT

PROJECT: STPD-6-2(122) Culbertson to McCook

CURVE NO.: 1-Open

CON. NO.: 70881

CONTRACT NO.: 7881

CONTRACTOR: Ten Point

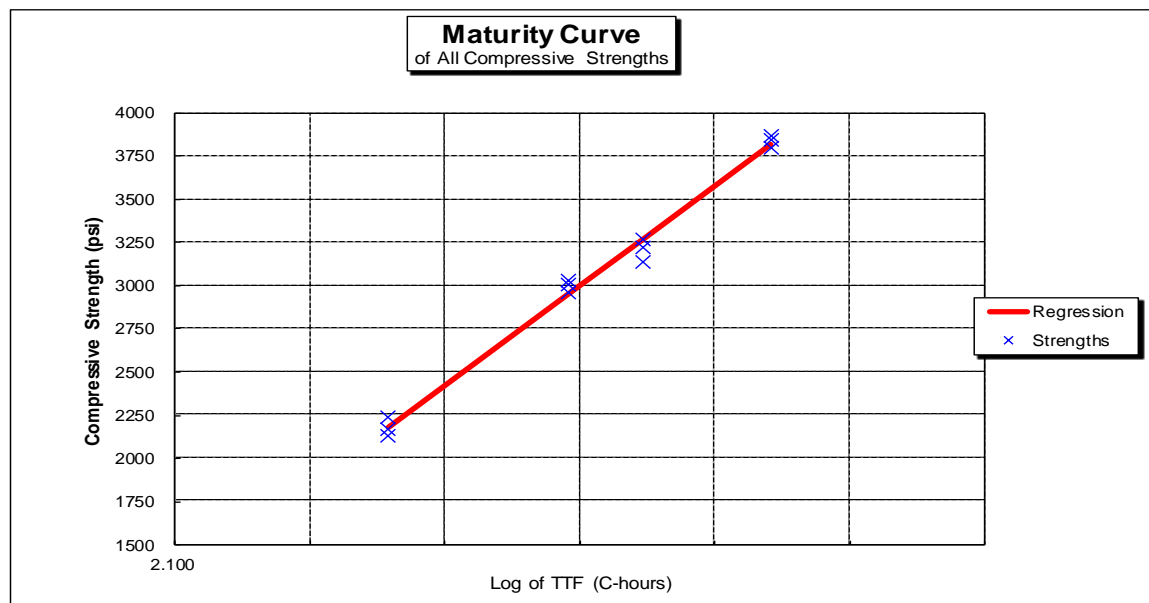
DATE: 06/11/11

Cylinder #	LOAD AT BREAK (lbs)	BREAK TYPE	Length (in)	Diameter (in)	Compressive STRENGTH (psi)	AGE AT BREAK (Hrs)	TTF CH 1	TTF CH 2	AVERAGE TTF	Cylinder TEMP (AVG)
	<b>Enter</b>		<b>Enter</b>	<b>Enter</b>		<b>Enter</b>	<b>Enter</b>	<b>Enter</b>		<b>Enter</b>
1	27260		8.00	4.00	2170	4	181	181	181	53 C
2	26720		8.00	4.00	2130	4	181	181	181	
3	28110		8.00	4.00	2240	4	181	181	181	
4	37180		8.00	4.00	2960	5	246	246	246	
5	38070		8.00	4.00	3030	5	246	246	246	
6	37870		8.00	4.00	3010	5	246	246	246	
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8	40420		8.00	4.00	3220	5.5	280	280	280	
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10	47810		8.00	4.00	3800	6.5	348	348	348	58 C
11	48640		8.00	4.00	3870	6.5	348	348	348	
12	48225		8.00	4.00	3840	6.5	348	348	348	



MIX INFORMATION	
	<b>Enter</b>
Mix:	PR1 W/ Liquid Calcium
AIR:	6.4
SLUMP:	
w/c:	
FLY ASH SOURCE:	
CEMENT SOURCE:	
COARSE AGGREGATE SOURCE:	
FINE AGGREGATE SOURCE:	
WATER REDUCER BRAND:	
Add. Rate:	
AIR ADMIXTURE BRAND:	
Add. Rate:	
METHOD OF DEVELOPMENT:	Cylinders / Cure Box
DESIRED COMP. STRENGTH (psi):	3000 psi

**REQUIRED MINIMUM TTF:** **251**



Certified Rep. & Company Name: Tim A. Krason, NDOR  
Signature

Certified Rep. & Company Name: \_\_\_\_\_  
Signature

**Comments:** Weather - Approx 74 F for High.

Added Glenium 3030 on site.

See sitemanager entry for mix information.



# STEPS FOR VALIDATING MATURITY CURVE

## Curve Validation

- Curve validation shall be performed approximately every 4 to 6 weeks during normal plant production and any change in the mix design.
- NDOR PCC Manager or Consultant will schedule the validation date with the PE and Field Inspectors.
- The Field Inspectors will be requested to make five cylinders on the validation scheduled date.
- The Field Inspector will need to embed two thermocouple wires into two concrete cylinders.
- The certified personnel will request that the Field Inspector document
  - The time the cylinders were cast .
  - The initial temperature of the cylinders.
- Test three cylinders as close as possible to the Required Minimum TTF that is from the most current maturity curve being used.

# NDOR VERIFICATION OF MATURITY CURVE - COMPRESSIVE STRENGTH DEVELOPMENT

PROJECT: STPD-6-2(122) Culbertson to McCook  
C.N.: 7881

CONTRACTOR: Ten Point

CURVE NO.: 1-Verify  
DATE: 7/11/2011

CYLINDER #	LOAD AT BREAK (lbs)	BREAK TYPE (in)	Length (in)	Diameter (in)	Compressive STRENGTH (psi)	AGE AT BREAK (Hrs)	TTF CH 1	TTF CH 2	AVERAGE TTF
1	Enter 42120		Enter 8.00	Enter 4.00	3350	Enter 5	Enter 265	Enter 265	265
2	41600		8.00	4.00	3310	5	265	265	265
3	41880		8.00	4.00	3330	5	265	265	265

MIX: PR1 W/ Liquid Calcium

AIR: 8

SLUMP:

w/c:

FLY ASH:

CEMENT:

COARSE AGGREGATE:

FINE AGGREGATE:

WATER REDUCER:

Add. Rate:

AIR ENTRAINER:

Add. Rate:

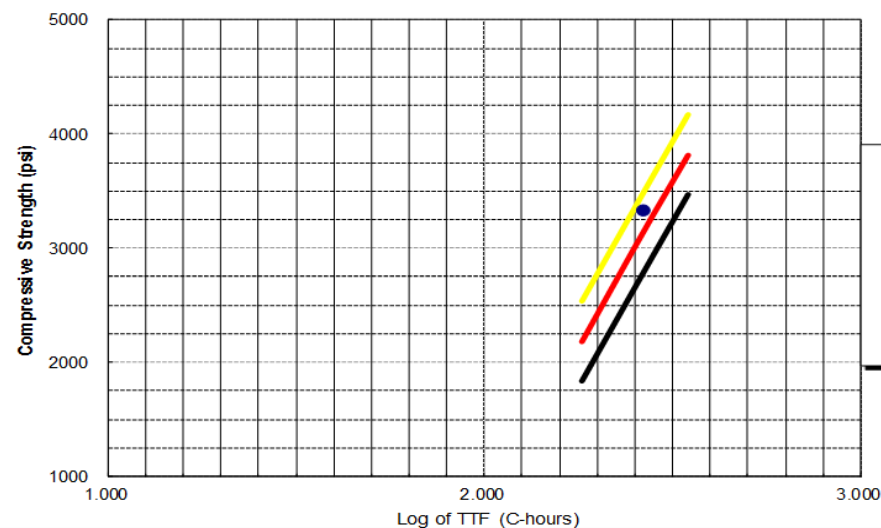
METHOD OF DEVELOPMENT: Cylinders / Cure Box

Enter

Enter

Enter

## Verification Curve of All Compressive Strengths



Regression  
Verification  
Upper Limit  
Lower Limit

### CURVE VERIFICATION

TTF @ Break	265
Cylinder 1 (psi)	3350
Cylinder 2 (psi)	3310
Cylinder 3 (psi)	3330
Avg. (psi)	3330

Maximum Difference Allowed (psi)

350

Calculated  
psi @ TTF

Range

3137

Minimum

2787

Maximum

3487

Curve Verification -

OK

Certified Rep. & Company Name: Tim A. Krason, NDOR

Signature

Certified Rep. & Company Name:

Signature

Comments:

See sitemanager entry for mix information.

It is ok to continue using the curve, it checked out above the lower limit.

Verification strength above the upper limit does not require a new curve.

# The NDOR M&R Website References

Materials & Research



Setting the Standard



# M&R Website References


## Website Link

<http://www.nebraskatransportation.org/mat-n-tests/>

- *Guidelines- Maturity Curve Method of Development.*

# The Materials and Research Website

## Guidelines-Maturity Curve Method of Development




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#### 2013 NCPA Concrete Workshop

- Presentation - Maturity Curve Method Of Development **Coming Soon!**

#### 2012 PM Conference Presentations

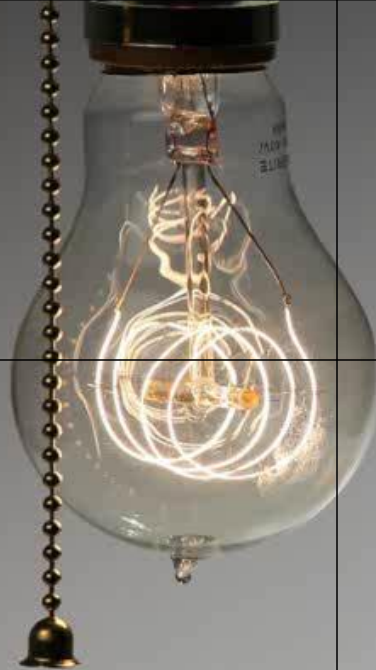
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# Consultants - Forms

LAN ACCOUNT

FCAC\Forms\M&R Forms

- ❑ *NDOR Maturity Method – Compressive Strength Development*
- ❑ *NDOR Validation of Maturity Curve – Compressive Strength Development*
- ❑ *Maturity Method - Field Data Spreadsheet*



# Questions

